

## EFFECTS OF BBN ON POPULATION III STARS

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The presence (or absence) of CNO elements in the primordial gas determines different behaviours in population III stars formation and evolution: we therefore present an analysis of the main channels for the synthesis of these elements in BBN in order to understand, within a reliable interval, their abundance in the primordial material.

### 1. Introduction

Recent studies on population III (popIII) showed how interesting this pregalactic generation of stars is for our overall understanding of cosmology: their contribution to the first structure formation and to reionization makes them an extremely promising topic, (see for example <sup>1</sup>). In light of the huge number of works published in the last years, (see <sup>2</sup> and references therein), it's likely to picture the population III as a self-killing generation of very massive stars, which evolve fastly and eventually explode as Pair Instability Supernovae, ejecting in the outer space the metals they have produced during their life, (see for example <sup>3</sup>). The initial mass function (IMF) of these stars is determined from the absence of metals in the material from which they form out: there is a threshold in the metallicity of the gas above which the IMF shows the usual Salpeter form, and below which the IMF is the top-heavy one shown from <sup>4</sup>. The paucity of metals affects also the evolution of popIII: as widely known stars more massive than 3-4  $M_{\odot}$  burn hydrogen via CNO cycle, so that the scarcity of CNO catalyzers in popIII forces the main sequence through an "unusual" pp burning of hydrogen, resulting in an expansion and extreme heating of the core <sup>5</sup>. This phenomenon shows a threshold in CNO elements abundance, above which the star experience a "normal" main sequence. In light of all this it would be extremely important to find out with reliable precision the amount of metals in the primordial gas.

### 2. Metal nucleosynthesis in BBN

The successes of BBN predictions, obtained comparing the theoretical estimates of light elements with the observed abundances, show the deep knowledge of nucleosynthesis phenomenon we have today -at least for what deals with light elements <sup>6</sup>. In particular the updating of the cross-section data and the knowledge of the

main synthesis channels is essential in order to estimate the primordial elemental abundances and their uncertainties. Such a precision in the light nuclide predictions is not yet available for the heavier CNO nuclides, nor in the connections between light and heavy elements. Historically this is due to the very low final abundance of these elements which does not justify an effort to determine them, as long as it is impossible to compare the predictions with observational data. In light of the importance of metals (and more specifically of CNO elements) in POPIII stars theory we have performed an analysis of the BBN network toward carbon, nitrogen and oxygen, identifying the main reaction channels and updating, where possible, the cross-section data with newest ones. Our study showed that the main channel for carbon production in stars, namely the  $2^4\text{He}(\alpha, \gamma)^{12}\text{C}$  which provides a direct connection between light and heavy elements, is suppressed in BBN as a consequence of the very low density of the plasma; we have identified as main channels for carbon synthesis the  $^7\text{Li}(\alpha, \gamma)^{11}\text{B}(p, \gamma)^{12}\text{C}$ ,  $^7\text{Li}(\alpha, \gamma)^{11}\text{B}(d, n)^{12}\text{C}$  and  $^7\text{Be}(\alpha, \gamma)^{11}\text{C}$ , together with the back reaction  $^{11}\text{C}(n, \alpha)^2^4\text{He}$  and  $^{11}\text{B}(p, \alpha)^2^4\text{He}$ ; heavier elements build up through progressive proton, deuteron and neutron captures upon carbon nuclei. These results, obtained by computing the contributions of the different reactions to the Boltzmann equation which describes the elemental abundance evolution, show that the heavy elements synthesis in BBN is strongly related to the intermediate element (such as *Li*, *Be* and *B*) one, thus emphasizing the necessity of a complete revision of the "intermediate" and "upper" part of the network. We have also noted that most of the reactions involving isotopes of hydrogen and helium but *H* and  $^4\text{He}$  are neglected in the existing code -at least for what deals with the "metal network"; we have added a first set of new reactions to study how they affect the heavy-nuclide synthesis, and results will be presented in a future paper.

## References

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